

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
7 July 2005 (07.07.2005)

PCT

(10) International Publication Number  
WO 2005/061904 A1

(51) International Patent Classification<sup>7</sup>: F15B 1/04,  
21/04, F17C 13/02, 13/08

(21) International Application Number:  
PCT/US2004/030968

(22) International Filing Date:  
22 September 2004 (22.09.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/504,188 22 September 2003 (22.09.2003) US

(71) Applicant (for all designated States except US): DANA  
CORPORATION [US/US]; 4500 Dorr Street, Toledo,  
Ohio 43615 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): ROSE, Kenric, B.  
[US/US]; 8516 N. Latson Road, Howell, Michigan 48855  
(US).

(74) Agents: STAVISH, Matthew et al.; Liniak, Berenato  
& White, 6550 Rock Spring Drive, Suite 240, Bethesda,  
Maryland 20817 (US).

(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,  
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,  
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,  
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,  
MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG,  
PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM,  
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM,  
ZW.

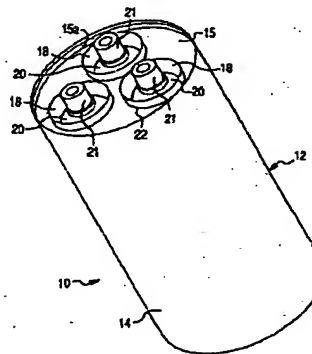
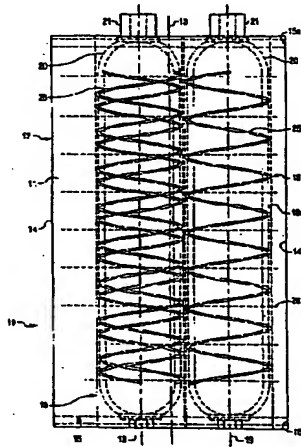
(84) Designated States (unless otherwise indicated, for every  
kind of regional protection available): ARIPO (BW, GH,  
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,  
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),  
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,  
FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SI, SK,  
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,  
GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report  
— before the expiration of the time limit for amending the  
claims and to be republished in the event of receipt of  
amendments

[Continued on next page]

(54) Title: PRESSURE VESSEL ASSEMBLY FOR INTEGRATED PRESSURIZED FLUID SYSTEM



(57) Abstract: A pressure vessel assembly for a pressurized fluid system, comprises an enclosed outer casing, at least one internal tube extending within the casing, at least one fluid accumulator disposed within the at least one internal tube, and at least one cooling passage provided within the at least one internal tube and defined by a clearance between the at least one hydraulic fluid accumulator and the at least one internal tube. The pressure vessel assembly further includes a fluid storage compartment formed between the outer casing and the at least one internal tube. The fluid storage compartment is at least partially filled with a working fluid. The pressurized fluid system also includes a cooling fan allowing forced airflow through the cooling passage for forced cooling of the at least one hydraulic fluid accumulator and the working fluid in the storage compartment of the pressure vessel assembly.

BEST AVAILABLE COPY



*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# PRESSURE VESSEL ASSEMBLY FOR INTEGRATED PRESSURIZED FLUID SYSTEM

## BACKGROUND OF THE INVENTION

5

### CROSS-REFERENCE TO RELATED APPLICATION

This Application claims the benefit under 35 U.S.C. 119(e) of U.S. Provisional Application No. 60/504,188 filed September 22, 2003 by Kenric Rose.

10

#### 1. Field of the Invention

The present invention relates to integrated pressurized fluid systems in general, such as for hydraulic regenerative drive systems, and, more particularly, to an integrated pressurized  
15 fluid system including a pressure vessel assembly containing at least one hydraulic fluid accumulator.

#### 2. Description of the Prior Art

20

In conventional integrated pressurized fluid systems the recovered energy is normally accumulated in flywheel accumulators, in electrochemical batteries or in hydraulic fluid accumulators. The latter are of known technology and, in comparison with the other recovery and accumulation arrangements, they are more flexible in use, notably in connection with a

vehicular transmission to which they are connected. On the other hand they remain less efficient in terms of mass and volume and consequently raise serious problems for fitting onto motor vehicles. In addition to penalizing the energy savings obtained, these problems of dead weight and bulk lead to high costs linked either with the hydraulic fluid accumulator itself or, 5 mainly, with the modifications that have to be made to the vehicle to fit the accumulator. The result is that the motor vehicles equipped with the hydraulic fluid accumulator are no longer standard in any way and are therefore much more expensive to produce and maintain and that, furthermore, the equipment used for this installation cannot be transposed to another vehicle or modulated in size, which increases the overall cost of such an installation.

10 Accordingly, it is the intent of this invention to overcome these shortcomings of the prior art by providing a compact pressure vessel assembly combining all the accumulation functions and capable of being fitted without any substantial modification to various types of pressurized fluid systems, including standard motor vehicles equipped with hydraulic regenerative drive system designed for charging and discharging the hydraulic fluid 15 accumulators.

## SUMMARY OF THE INVENTION

The present invention provides a pressure vessel assembly for use in an integrated 20 pressurized fluid system, such as for a hydraulic regenerative drive system.

The pressure vessel assembly of the present invention comprises an enclosed outer casing, at least one internal tube extending within the casing, at least one fluid accumulator

disposed within the at least one internal tube, and at least one cooling passage provided within the at least one internal tube and defined by a clearance between the at least one hydraulic fluid accumulator and the at least one internal tube. The pressure vessel assembly further includes a fluid storage compartment formed within the outer casing outside the at least one  
5 internal tube. The fluid storage compartment is at least partially filled with a working fluid, such as oil.

The pressurized fluid system of the present invention includes a cooling fan allowing forced airflow through the cooling passage for forced cooling of the at least one hydraulic fluid accumulator and the working fluid in the storage compartment of the pressure vessel  
10 assembly.

The pressurized fluid system of the present invention further includes a pressurized gas reservoir external to the outer casing so that the pressurized gas reservoir is in fluid communication with the compartment within the outer casing for pressurizing the working fluid within the compartment in the outer casing.

15 Moreover, according to the preferred embodiment of the present invention, the hydraulic fluid accumulator is placed inside the internal tube, centered and spaced inside the internal tube with at least one spiral wrapping around the hydraulic fluid accumulator.

Furthermore according to the preferred embodiment of the present invention, the outer casing of the pressure vessel includes a substantially tubular housing and end members  
20 secured at opposite distal ends of the housing.

## BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent from a study of the following specification when viewed in light of the accompanying drawings, wherein:

5        Fig. 1 is a schematic view of an integrated pressurized fluid system in accordance with the present invention;

      Fig. 2 is a cross sectional view of a pressure vessel assembly in accordance with the preferred embodiment of the present invention;

10       Fig. 3 is a rear view of the pressure vessel assembly in accordance with the preferred embodiment of the present invention;

      Fig. 4 is a perspective view from the front of the pressure vessel assembly in accordance with the preferred embodiment of the present invention;

      Fig. 5 is a perspective view from the rear of the pressure vessel assembly in accordance with the preferred embodiment of the present invention;

15       Fig. 6 is a cross sectional view of an internal tube containing a hydro-pneumatic accumulator in accordance with the preferred embodiment of the present invention;

      Fig. 7 is a perspective view from the front of the internal tube with a perforated cover member in accordance with the preferred embodiment of the present invention.

## 20       DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The preferred embodiment of the present invention will now be described with the

reference to accompanying drawings.

Fig. 1 schematically depicts an integrated pressurized fluid system, such as for a hydraulic regenerative drive system. However, it is to be understood that while the present invention is described in relation to the hydraulic regenerative drive system, the present

5. invention is equally suitable for use in any appropriate pressurized fluid system.

As illustrated in Fig. 1, the integrated pressurized fluid system 1 in accordance with the preferred embodiment of the present invention comprises a pressure vessel assembly 10, and a motor/pump 2 in fluid communication with the pressure vessel assembly 10. An external source of the kinetic energy (not shown) is drivingly connected to the motor/pump 2  
10 through a drive shaft 3.

Preferably, the motor/pump 2 is a positive displacement, reversible hydraulic unit, such as a high-pressure hydraulic piston machine that functions both as hydraulic pump and hydraulic motor when reversed. Alternatively, the motor/pump 2 is a variable-displacement hydraulic unit. It will be appreciated that any appropriate hydraulic motor/pump unit is within  
15 the scope of the present invention. In the application for the hydraulic regenerative drive system of a motor vehicle (not shown), the motor/pump 2 is connected to a driveline of the motor vehicle through the drive shaft 3.

As further illustrated in Fig. 1, the pressure vessel assembly 10 houses at least one, but preferably a plurality of hydraulic fluid accumulators 20 and defines a working fluid storage  
20 compartment 11 therewithin at least partially filled with a working hydraulic fluid 17, such as oil, at either atmospheric, or low-pressure. It will be appreciated that any appropriate type of the hydraulic fluid accumulators may be employed. Preferably, the hydraulic fluid

accumulators 20 are hydro-pneumatic accumulators known in the art. Each of the hydro-pneumatic accumulators 20 has a communication port 21 connected to the motor/pump 2, and a gas charging port 23.

Further preferably, the hydraulic fluid 17 in the storage compartment 11 of the pressure vessel assembly 10 is at low-pressure created by an external pressurized gas reservoir 6 fluidly communicating with the storage compartment 11, as illustrated in Fig. 1. Preferably, the external pressurized gas reservoir 6 is in the form of a low-pressure gas accumulator or a gas bottle containing an appropriate gas under pressure. Thus, the storage compartment 11 of the pressure vessel assembly 10 makes up a low-pressure accumulator connected to the motor/pump 2. Further preferably, the pressure vessel assembly 10 houses three hydraulic fluid accumulators 20 fluidly connected to the motor/pump 2. As further shown in Fig. 1, the motor/pump 2 is fluidly connected to both the hydraulic fluid accumulators 20 through a distribution block 7 and to the storage compartment 11 of the pressure vessel assembly 10.

The pressure vessel assembly 10, shown in detail in Figs. 2-5, comprises an enclosed outer casing 12 housing the fluid accumulators 20. The outer casing 12 includes a tubular, preferably a substantially cylindrical, housing 14 having a central axis 13 and opposite end members 15 and 16. Alternatively, the tubular housing 14 may have oval, rectangular, square, or any other appropriate cross-section. Preferably, the end members 15 and 16 are in the form of substantially flat plates provided with flanges 15a and 16a, respectively, as shown in Figs. 2, 4 and 5, which are firmly secured to opposite distal ends of the housing 12, such as by welding, so as to be leak tight to a desired pressure rating of the pressure vessel assembly 10. The pressure vessel assembly 10 is designed such that the material thickness of the housing 12



and welds are sufficient to contain a working pressure of the hydraulic fluid 17 in the storage compartment 11 within the outer casing 12 of the pressure vessel assembly 10 with an appropriate safety factor.

The outer casing 12 of the pressure vessel assembly 10 is further provided with a plurality of smaller diameter, cylindrical internal tubes 18 secured therewithin. Each of the plurality of the cylindrical internal tubes 18 has a longitudinal axis 19 substantially parallel to the central axis 13 of the cylindrical housing 14 and is sized to receive one of the hydraulic fluid accumulators 20 that fit inside the internal tube 18 with a nominal clearance. The clearance between the hydraulic fluid accumulator 20 and the internal tube 18 defines a cooling passage for receiving a flow of an appropriate cooling fluid, such as air, therethrough for cooling the hydraulic fluid accumulator 20 and the working hydraulic fluid within the storage compartment 11 of the pressure vessel assembly 10. Preferably, the nominal clearance is on the order of one-quarter of an inch.

Further preferably, the internal tubes 18 have substantially the same length as the housing 12 and extend through the flat end members 15 and 16. All the internal tubes 18 are assembled such that their ends are flush. In order to achieve this, corresponding circular holes 22 are punched in each of the end members 15 and 16 of the pressure vessel assembly 10 to accommodate the internal tubes 18. Thus, the working fluid storage compartment 11 is defined by a space between an inner peripheral surface 14a of the cylindrical housing 14, an outer peripheral surface 18a of the internal tubes 18, and the end members 15 and 16.

The hydraulic fluid accumulators 20 are secured within the internal tubes 18 of the pressure vessel assembly 10 by any appropriate means known to those skilled in the art. By

way of example, distal ends of the internal tubes 18 may be closed with perforated circular cover members 25 (shown in Figs. 6 and 7) attached to the opposite distal ends of the internal tubes 18, such as by threaded fasteners or welding, so as to firmly secure the hydraulic fluid accumulators 20 within of the pressure vessel assembly 10. As illustrated, each of the cover members 25 is provided with a plurality of cooling holes 27 allowing cooling flow through the cooling passage within the internal tube 18.

In an assembled condition, the end members 15 and 16 are inserted into the cylindrical housing 14 and aligned such as to be parallel to each other and perpendicular to the central axis 13 of the housing 14. The end members 15 and 16 are recessed sufficiently such that sufficient weld material can be applied between the raised flange 15a and 16a of the end plates 15 and 16, respectively, and an inner peripheral surface 14a of the cylindrical housing 14. At the time of alignment of the end plates 15 and 16, the punched circular holes 22 in both end members 15 and 16 must be aligned such that the internal tubes 18 may be passed through the completed cylindrical housing 14 and the end members 15, 16 and aligned flush with the cylindrical housing 14. Once the internal tubes 18 are positioned, sufficient weld is applied to the raised flange 15a and 16a of the end plates 15 and 16 and the distal ends of the cylindrical housing 14 so as to be leak tight to the desired pressure rating of the pressure vessel assembly 10. The pressure vessel assembly 10 shall be designed such that the material thickness and welds are sufficient to contain the working pressure of the system with an appropriate safety factor.

The pressure vessel assembly 10 of the pressurized fluid system 1 according to the preferred embodiment of the present invention further allows for efficient cooling of the

housing 12 of the pressure vessel assembly 10 via forced airflow through the pressure vessel assembly 10. For this purpose, as illustrated in Fig. 1, the pressurized fluid system 1 includes a cooling fan 4 allowing an air flow F through the cooling passage defined by the clearance between the hydraulic fluid accumulator 20 and the internal tube 18 for forced cooling of the hydraulic fluid accumulators 20, the internal tubes 18 and the storage compartment 15 of the pressure vessel assembly 10 through the outer peripheral surface 18a of the internal tubes 18. Preferably, the cooling fan 4 is selectively driven by an electric motor 5 that, in turn, is selectively operated by an electronic controller (not shown). Thus, the air flow F of the cooling fan 4 provides a forced heat transfer from outer peripheral surfaces of the hydraulic accumulators 20.

Moreover, according to the preferred embodiment of the present invention, the hydraulic fluid accumulators 20 are placed inside the internal tubes 18, centered and spaced inside the internal tubes 18 with at least one, preferably two, spiral wrappings 26 around the hydraulic fluid accumulators 20, as illustrated in Fig. 2. The nature of these wrappings 26 shall secure the hydraulic fluid accumulators 20 inside the internal tubes 18 and also allow for forced air circulation between an inner peripheral surface of the internal tubes 18 and an outer peripheral surface of the hydraulic fluid accumulators 20. Thus, the spiral wrappings 26 increase efficiency of the cooling of the hydraulic accumulators 20 and the working hydraulic fluid 17 within the storage compartment 11 of the pressure vessel assembly 10 by contributing to both the turbulence of the forced air flow F and serving to lengthen the path that the forced air flow F and therefore increase the time in which the forced air flow F and the internal tubes 18 and the accumulators 18 are in contact, thus increasing heat transfer. Preferably, the spiral

wrappings 26 are made of an elastomeric material for dampening vibrations of the hydraulic accumulators 20 within the internal tubes 18.

Furthermore, a number of internal baffles 28 within the outer casing 12 are employed to increase a rate of thermal conduction from the working hydraulic fluid 17 within the storage compartment 11 of the pressure vessel assembly 10 to the internal tubes 18, reduce the amount of the hydraulic fluid movement within the storage compartment 11, and strengthen the pressure vessel assembly 10. It will be appreciated by those of ordinary skill in the art that arrangement of the internal baffles 28 can be varied to accommodate various angles of inclination of the motor vehicle.

10 The entire pressurized fluid system 1 is scaled such that sufficient working hydraulic fluid 17 may be contained within the storage compartment 11 of the pressure vessel assembly 10 between the inner peripheral surface 14a of the housing 14, the outer peripheral surface 18a of the internal tubes 18, and the end members 15 and 16 to allow the accumulators 20 to be charged with fluid.

15 Care shall be used in the selection of the materials and thickness of the pressure vessel elements to optimize both the pressure capacity as well as the heat transfer capacity of the pressure vessel assembly 10.

The cylindrical design of the pressure vessel assembly 10 also optimizes pressure capacity as a function of system weight. The flat end members 15 and 16 with the raised lips 20 15a and 16a, respectively, around the circumference strengthen the external connection to the cylindrical housing 12 as well as the connections to the internal tubes 18.

The design also allows for increased protection of the hydraulic fluid accumulators 20. This protection consists of the cylindrical housing 14, the working hydraulic fluid 17, and the internal tubes 18, as well as the separation distances. The design is intended to increase the protection of the charged accumulators 20 from ballistic penetration. In addition to this  
5 protection the design also allows for the re-direction of any fluid discharged from the punctured accumulator. The nature of the design directs the flow of any working fluid out the ends of the pressure vessel assembly 10. Prudent placement/orientation of the complete system would direct any expelled fluid flow in a safe direction.

Therefore, the integrated pressurized fluid system in accordance with the present  
10 invention includes a novel pressure vessel assembly comprising an enclosed outer casing, at least one internal tube extending within the casing, at least one fluid accumulator disposed within the at least one internal tube, and at least one cooling passage provided within the at least one internal tube adjacent to the at least one fluid accumulator for receiving a flow of a cooling fluid therethrough for cooling the at least one fluid accumulator.

15 The foregoing description of the preferred embodiment of the present invention has been presented for the purpose of illustration in accordance with the provisions of the Patent Statutes. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiments disclosed hereinabove were chosen in order to best illustrate the principles  
20 of the present invention and its practical application to thereby enable those of ordinary skill in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated, as long as the principles described herein are

followed. Thus, changes can be made in the above-described invention without departing from the intent and scope thereof. It is also intended that the scope of the present invention be defined by the claims appended thereto.

What is claimed is:

1. A pressure vessel assembly for a pressurized fluid system, said pressure vessel assembly comprising:  
5       an enclosed outer casing;  
      at least one fluid accumulator disposed within said outer casing; and  
      at least one cooling passage provided adjacent to said at least one fluid accumulator for receiving a flow of a cooling fluid therethrough for cooling said at least one fluid accumulator.

10       2. The pressure vessel assembly as defined in claim 1, further including at least one internal tube extending within said outer casing, wherein said at least one fluid accumulator is disposed within said at least one internal tube.

15       3. The pressure vessel assembly as defined in claim 2, wherein said outer casing includes a substantially tubular housing and end members secured at opposite distal ends of said housing.

20       4. The pressure vessel assembly as defined in claim 3, wherein said at least one internal tube extends between said end members.

      5. The pressure vessel assembly as defined in claim 3, wherein said at least one internal tube extends through said end members

6. The pressure vessel assembly as defined in claim 2, wherein said at least one cooling passage is formed within said at least one internal tube.

7. The pressure vessel assembly as defined in claim 6, wherein said at least one fluid accumulator is disposed within said at least one internal tube with a clearance defining said at least one cooling passage.

8. The pressure vessel assembly as defined in claim 7, further including at least one spiral wrapping between said at least one internal tube and said at least one fluid accumulator, said at least one spiral wrapping directs said flow of said cooling fluid through said cooling passage for increasing heat transfer from said pressure vessel to said cooling fluid.

9. The pressure vessel assembly as defined in claim 8, wherein said at least one spiral wrapping is made of an elastomeric material.

10. The pressure vessel assembly as defined in claim 1, wherein said pressurized fluid system includes a cooling fan providing a forced air flow through said at least one cooling passage.

11. The pressure vessel assembly as defined in claim 1, wherein said pressure vessel defines a compartment therewithin at least partially filled with a working fluid.



12. A pressure vessel assembly for a pressurized fluid system, said pressure vessel comprising:

an enclosed outer casing;

at least one internal tube extending within said outer casing; and

5 at least one fluid accumulator disposed within said at least one internal tube.

13. The pressure vessel assembly as defined in claim 12, wherein said pressure vessel defines a compartment therewithin between said outer casing and said at least one internal tube, said compartment at least partially filled with a working fluid.

10

14. The pressure vessel assembly as defined in claim 1, wherein said outer casing includes a substantially tubular housing and end members secured at opposite distal ends of said housing.

15

15. The pressure vessel assembly as defined in claim 14, wherein said tubular housing is substantially cylindrical in shape.

16. The pressure vessel assembly as defined in claim 12, further including at least one cooling passage adjacent to said at least one fluid accumulator for receiving a flow of cooling  
20 fluid therethrough for cooling said at least one fluid accumulator.

17. The pressure vessel assembly as defined in claim 16, wherein said at least one cooling passage is formed within said at least one internal tube.

18. The pressure vessel assembly as defined in claim 17, wherein said at least one fluid accumulator is disposed within said at least one internal tube with a clearance defining said at least one cooling passage.

5        19. The pressure vessel assembly as defined in claim 18, further including at least one spiral wrapping between said at least one internal tube and said at least one fluid accumulator, said at least one spiral wrapping directs said flow of said cooling fluid through said cooling passage for increasing heat transfer from said pressure vessel to said cooling fluid.

10       20. The pressure vessel assembly as defined in claim 8, wherein said at least one spiral wrapping is made of an elastomeric material.

15       21. The pressure vessel assembly as defined in claim 16, wherein said pressurized fluid system includes a cooling fan providing a forced air flow through said at least one cooling passage.

22. The pressure vessel assembly as defined in claim 14, wherein said at least one internal tube extends between said end members.

20       23. The pressure vessel assembly as defined in claim 14, wherein said at least one internal tube extends through said end members.

24. The pressure vessel assembly as defined in claim 12, wherein said outer casing includes at least one internal baffle.

25. The pressure vessel assembly as defined in claim 12, wherein said at least one fluid  
5 accumulator is a hydro-pneumatic accumulator.

26. A pressure vessel assembly for a pressurized fluid system, said pressure vessel assembly comprising:

an enclosed outer casing;

10 at least one fluid accumulator disposed within said outer casing;

a compartment within said pressure vessel assembly between said outer casing and said at least one fluid accumulator, said compartment at least partially filled with a working fluid;

said compartment being in fluid communication with said at least one fluid  
15 accumulator so as to selectively transfer said working fluid between said compartment and said at least one fluid accumulator; and

a pressurized gas reservoir external to said outer casing, said pressurized gas reservoir being in fluid communication with said compartment within said outer casing for pressurizing said working fluid within said compartment in said outer casing.

20

27. The pressure vessel assembly as defined in claim 26, wherein said compartment includes at least one internal baffle.

28. The pressure vessel assembly as defined in claim 26, wherein said working fluid is oil.

29. The pressure vessel assembly as defined in claim 26, wherein said outer casing  
5 includes a substantially tubular housing and end members secured at opposite distal ends of said housing.

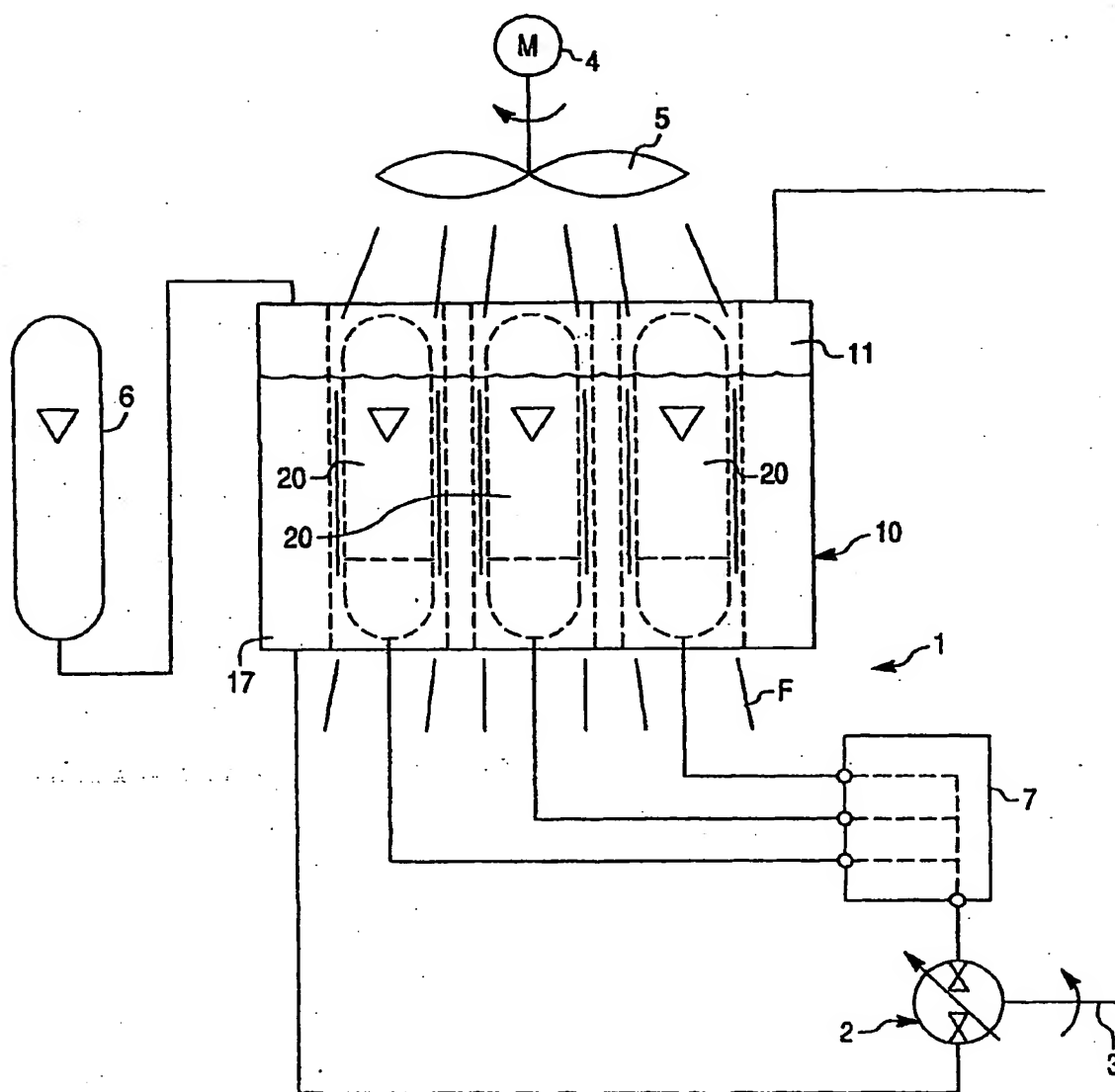
30. The pressure vessel assembly as defined in claim 29, wherein said at least one internal tube extends between said end members.

10

31. The pressure vessel assembly as defined in claim 29, wherein said at least one internal tube extends through said end members.

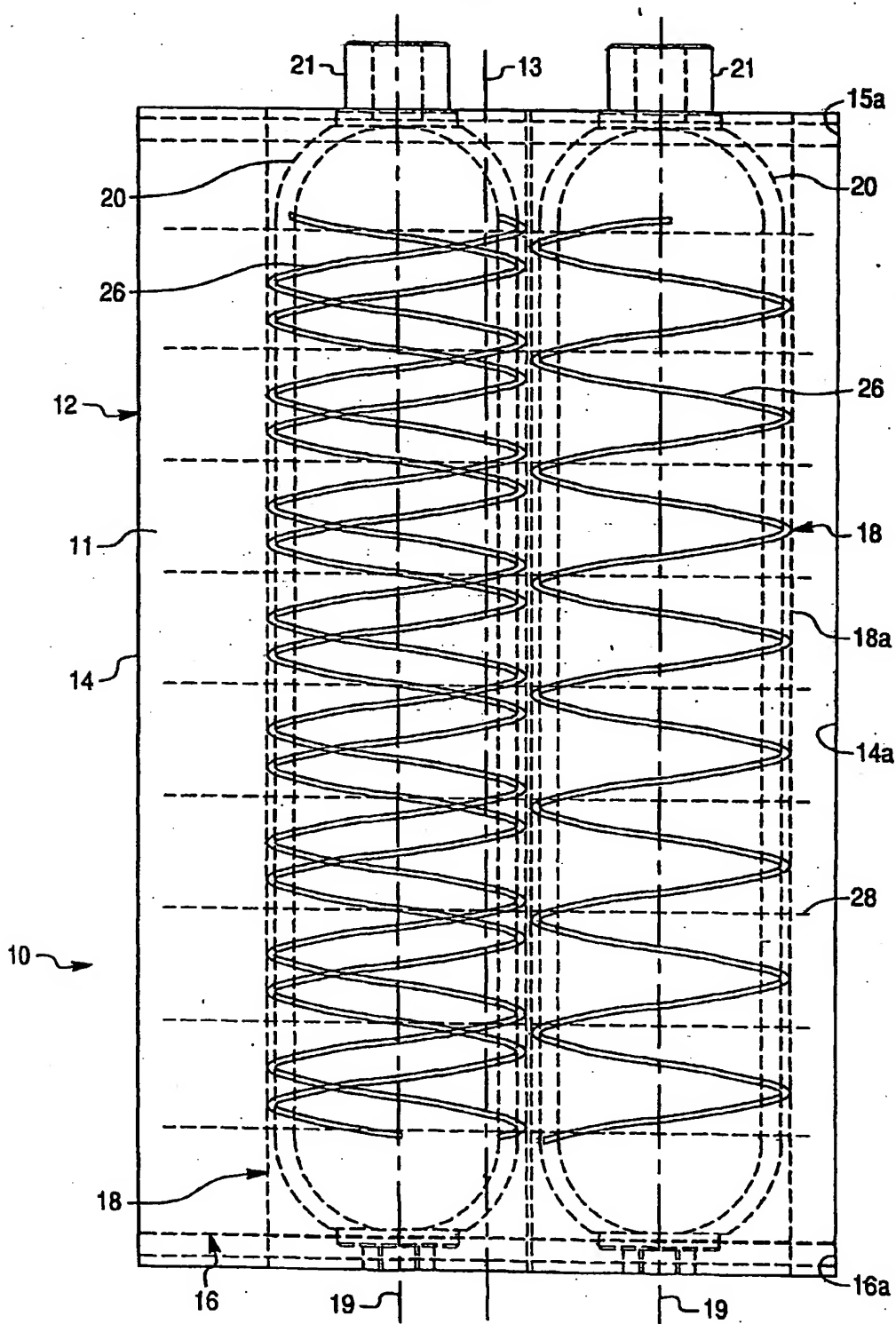
32. The pressure vessel assembly as defined in claim 26, wherein said outer casing  
15 includes at least one internal baffle.

33. The pressure vessel assembly as defined in claim 26, wherein said pressurized fluid system includes a hydraulic machine having a first port fluidly connected to said at least one fluid accumulator and a second port fluidly connected to working fluid in said said  
20 compartment.

1/6  
Fig. 1

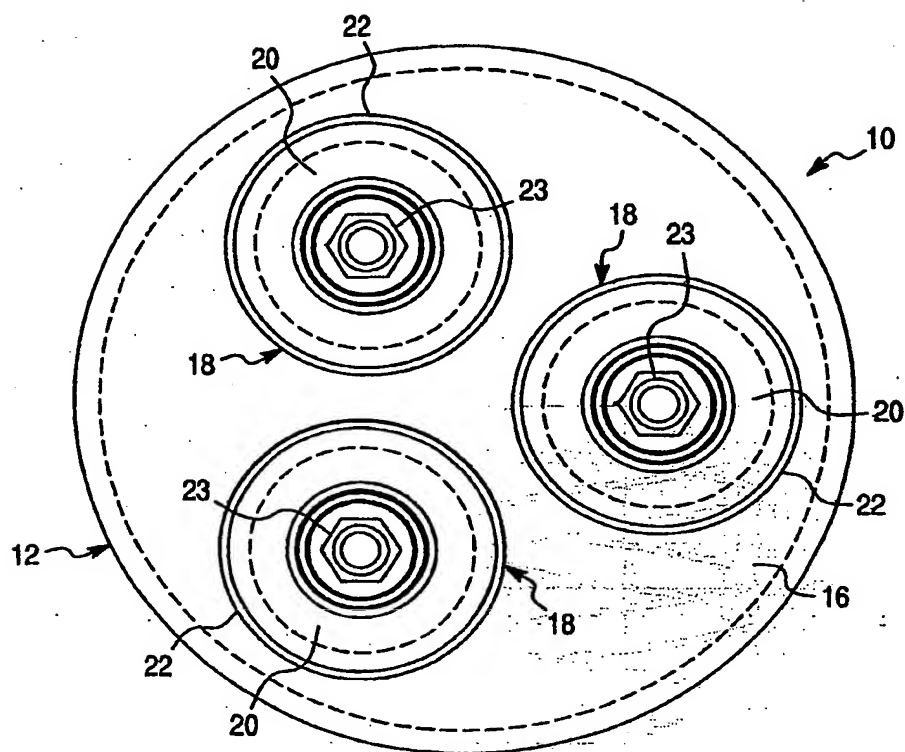
2/6

Fig. 2



SUBSTITUTE SHEET (RULE 26)

Fig. 3



4/6

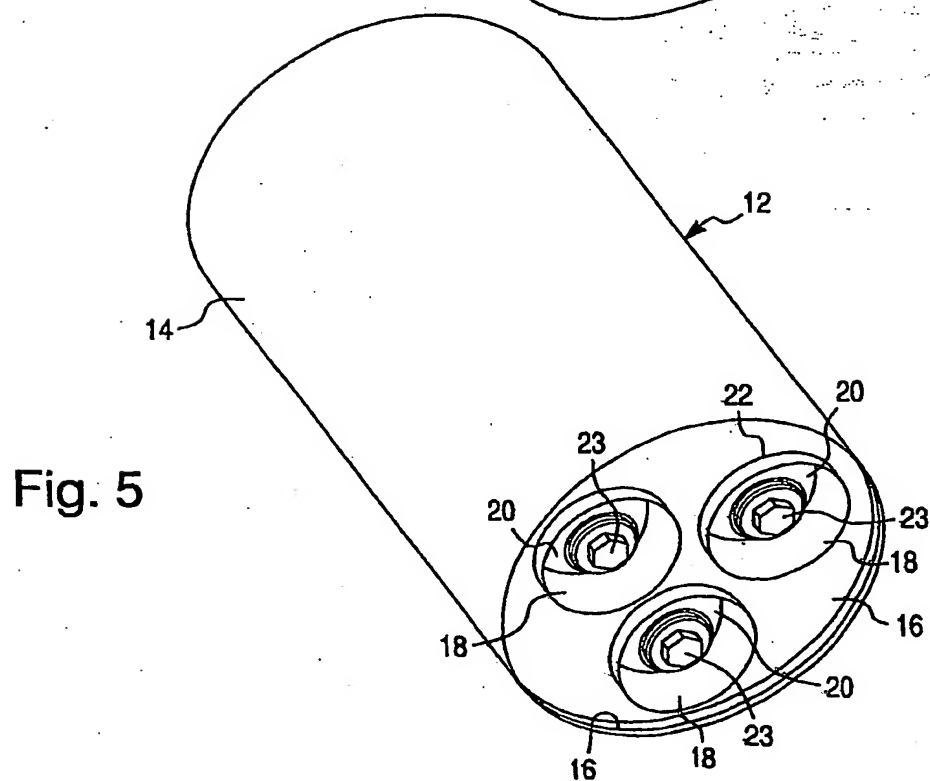
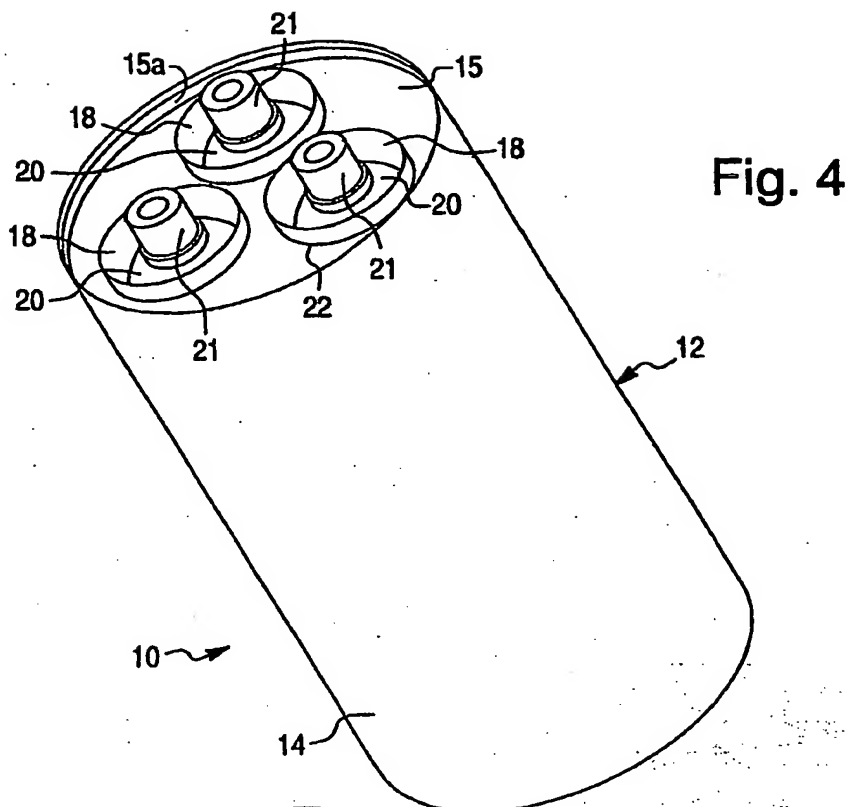
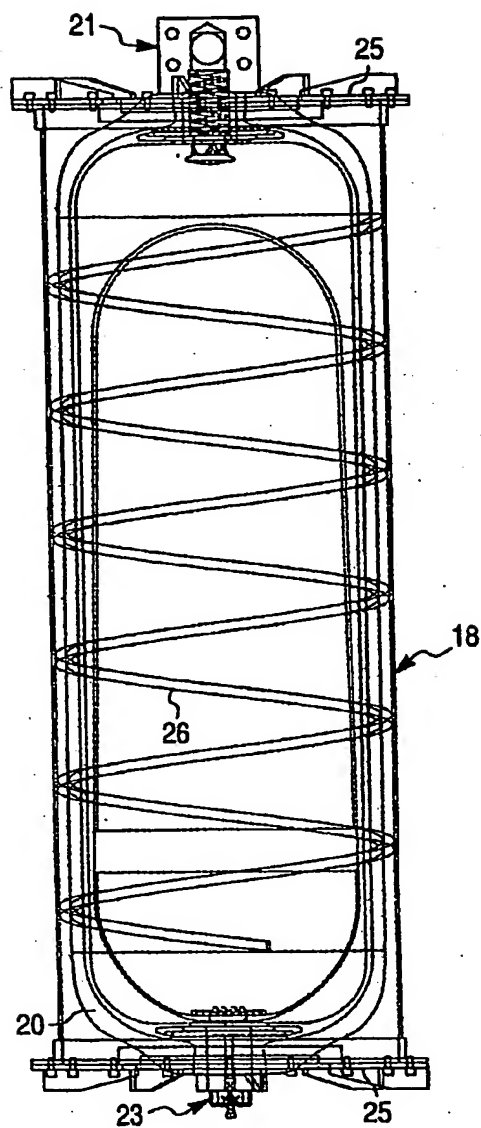




Fig. 6



SUBSTITUTE SHEET (RULE 26)

6/6

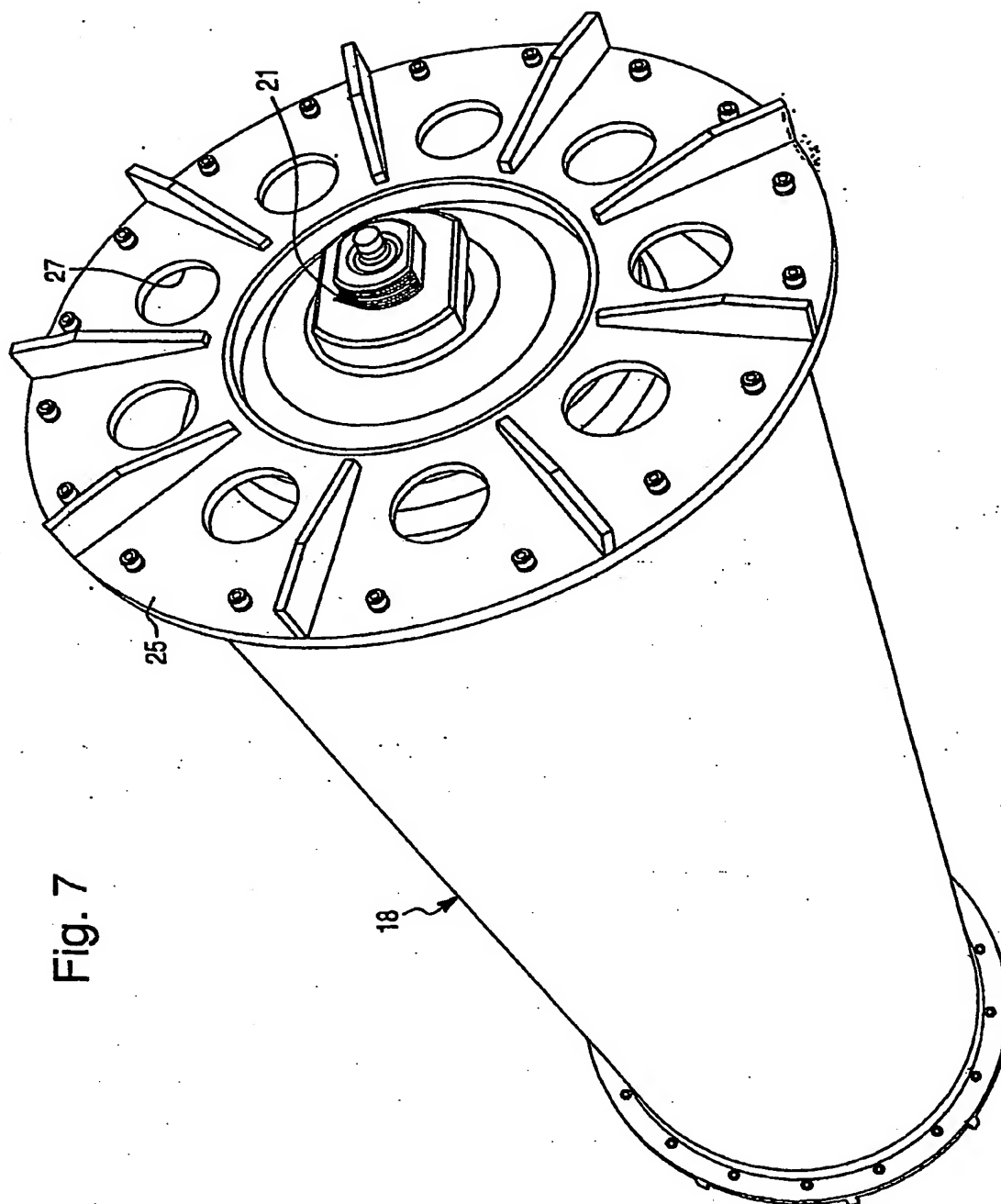


Fig. 7

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US2004/030968

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F15B1/04 F15B21/04 F17C13/02 F17C13/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F15B F17C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 791 766 A (KIKUTSUGI A ET AL) 12 February 1974 (1974-02-12) the whole document	1,10,11
X	DE 100 41 131 A (GEESTHACHT GKSS FORSCHUNG ; ANDERS DIETRICH (DE)) 21 March 2002 (2002-03-21) the whole document	1,2,6,7
X	EP 0 047 336 A (OLSSON LARS UNO) 17 March 1982 (1982-03-17) page 3, line 16 - line 24 page 4, line 18 - line 23 page 5, line 24 - page 7, line 30	1,2,6,7, 10,11
Y		3-5,8,9, 20
	-/--	

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*Z\* document member of the same patent family

Date of the actual completion of the international search

21 January 2005

Date of mailing of the international search report

29.04.2005

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel (+31-70) 340-2040, Tx 31 651 epo nl  
Fax (+31-70) 340-3016

Authorized officer

Nicol, B

## INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/US2004/030968

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 893 995 A (WATERS STEVE W) 13 April 1999 (1999-04-13) the whole document	3-5
Y	DE 553 586 C (BOCHUMER EISEN HEINTZMANN; HEINRICH TOUSSAINT) 28 June 1932 (1932-06-28) the whole document	8,9,20
X	DE 12 80 507 B (KRUPP GMBH) 17 October 1968 (1968-10-17) the whole document	1,2
A	US 6 158 234 A (SZUTU HUI JEN) 12 December 2000 (2000-12-12)	
A	US 6 029 741 A (SANO YOSHIHIRO ET AL) 29 February 2000 (2000-02-29)	

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2004/030968

## Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-11, 20

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-11,20

A pressure vessel assembly for a pressurized fluid system, said pressure vessel assembly comprising an enclosed outer casing, at least one fluid accumulator disposed within said outer casing, and at least one cooling passage provided adjacent to said at least one fluid accumulator for receiving a flow of a cooling fluid therethrough for cooling said at least one fluid accumulator.

---

2. claims: 12-19,21-25

A pressure vessel assembly for a pressurized fluid system, said pressure vessel comprising an enclosed outer casing, at least one internal tube extending within said outer casing, and at least one fluid accumulator disposed within said at least one internal tube.

---

3. claims: 26-33

A pressure vessel assembly for a pressurized fluid system, said pressure vessel assembly comprising an enclosed outer casing, at least one fluid accumulator disposed within said outer casing, a compartment within said pressure vessel assembly between said outer casing and said at least one fluid accumulator, said compartment at least partially filled with a working fluid, and said compartment being in fluid communication with said at least one fluid accumulator so as to selectively transfer said working fluid between said compartment and said at least one fluid accumulator, and a pressurized gas reservoir external to said outer casing, said pressurized gas reservoir being in fluid communication with said compartment within said outer casing for pressurizing said working fluid within said compartment in said outer casing.

---

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US2004/030968

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 3791766	A	12-02-1974	JP 47010902 U DE 2207678 A1 GB 1329395 A SE 372599 B	09-10-1972 14-09-1972 05-09-1973 23-12-1974
DE 10041131	A	21-03-2002	DE 10041131 A1	21-03-2002
EP 0047336	A	17-03-1982	EP 0047336 A1	17-03-1982
US 5893995	A	13-04-1999	NONE	
DE 553586	C	28-06-1932	NONE	
DE 1280507	B	17-10-1968	NONE	
US 6158234	A	12-12-2000	NONE	
US 6029741	A	29-02-2000	JP 11166697 A	22-06-1999

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☒ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**